neously connected with R. cornuta by European experimenters. R. cornuta as it occurs in this country on Sorbus, Amelanchier and P. arbutifolia either represents variations in the æcidia of G. globosum or results from the true G. conicum which has been hitherto overlooked.

NOTE.—Since the above was in press the writer has found the Rœstelia of the "bird's nest" Gymnosporangium growing simultaneously with R. lacerata very abundantly on Amelanchier, thus confirming the view above expressed. Further details will be given in a subsequent paper, together with notes on cultures made during the present year.

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Flowers and Insects. II.

CHARLES ROBERTSON.[1]

Viola pubescens Ait. (fig. 1).—Müller regards the yellow violets as nearest the primitive type. This is yellow with dark nectar-lines. The petaline spur is little more than a gibbosity. The nectar-secreting processes of the lower stamens are very short, being much wider than long. The summit of the peduncle and the flower axis are strongly curved so as to throw the spur well backwards, giving the flower a characteristic appearance, and this serves to limit the insect visits much more than the mere length of the spur. The tips of the anthers and the style are closely approximated to the spurred petal and obstruct the entrance, so that insects unaccustomed to the flower are effectually baffled in their attempts to reach the nectar. The lateral petals are bearded.

FIGURE 1.

The stigma is nearer the anthers than in V. palmata and V. striata, and self-fertilization in case of insect-absence is more probable.

A proboscis 3 mm. long can secure the nectar, if the bee forces its head in as far as the anthers. Bees receive the pollen mainly on the under side of the head, and work it back into their scopæ, when collecting it. After visiting several flowers, Osmia settles upon a fallen leaf and applies the pollen to her ventral scopa, and then returns to the flowers.

After watching the flowers on six days, between April 16 and 30, I obtained only six visitors; but on April 20, 1889, in two hours watching I added twelve new names.

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[1]On the fertilization of the genus see Müller: Fertilization of Flowers, 117-121 and 634.

Hymenoptera—*Apidæ:* (1) Anthophora ursina Cress. ♀, s., once; (2) Synhalonia honesta Cress. ♀, s., once; (3) Ceratina dupla Say ♀, s., once; (4) Osmia albiventris Cress. ♂ ♀ (=O. rustica Cress. ♂), s. and c. p., very ab.; (5) O. atriventris Cress. ♀, s. and c. p., ab.; (6) Nomada bisignata Say ♀, once. *Andrenidæ:* (7) Andrena sp. ♀, s. and c. p., once; (8) Augochlora pura Say ♀, s. and c. p., ab.; (9) Halictus coriaceus Sm. ♀ s.; (10) H. fasciatus Nyl? ♀, s; (11) H. pilosus Sm. ♀, s. and c. p.; (12) H. connexus Cress. ♀, s.; (13) H. stultus Cress. ♀, s. and c. p.

Diptera — *Bombylidæ:* (14) Bombylius fratellus Wied., s., ab. *Tachinidæ:* (15) Gonia frontosa Say, s., once.

Lepidoptera—*Rhopalocera:* (16) Colias philodice Godt.; (17) Nisoniades juvenalis F.; (18) N. martialis Scud. All sucked in a reversed position, except nos. 1, 14 and 16–18. Paragus tibialis, Melanostoma obscurum and Mesograpta marginata (Syrphidæ) eat stray pollen.

Viola palmata L. var. *cucullata* Gray (fig. 2).—This is our common blue violet. The lateral petals are bearded. The stigma touches the bee in advance of the anthers, and cross-fertilization is the natural result of insect visits. The staminal processes measure 3mm. and the spur about 4mm. The nectar is more deeply concealed than in V. pubescens, and, as a consequence, the list shows more long tongues.

FIGURE 2.

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, once; (2) Bombus separatus Cress. ♀; (3) B. pennsylvanicus De G. ♀; (4) Synhalonia speciosa Cress. ♂; (5) S. honesta Cress. ♀; (6) Ceratina dupla Say ♀, all sucking; (7) Osmia albiventris Cress. ♂ ♀, s. and c. p., ab.; (8) O. atriventris Cress ♀, s. and c. p., ab.; (9) Nomada vincta Say ♀, s. *Andrenidæ:* (10) Andrena sp. ♂ ♀, s. and c. p., ab.; (11) Halictus sp. ♀, s.; (12) H. fasciatus Nyl? ♀, s.

Diptera—*Bombylidæ*: (13) Bombylius fratellus Wied., s.

Lepidoptera—*Rhopalocera:* (14) Pyrameis huntera F.; (15) Colias philodice Godt.; (16) Pieris rapæ L.; (17) Nisoniades juvenalis F.; (18) N. martialis Scud. All sucked head downwards except nos. 6, 11 and 13; nos. 14–18 sometimes upright, sometimes reversing. Observed on nine days, between April 9 and 29.

Viola striata Ait. (fig. 3).—The flower is yellowish white, a few purplish lines on the lower petal forming nectar-guides. The lateral petals are bearded. The stigma is far in advance of the anthers, so that self-pollination is prevented. The spur is considerably longer than in V. palmata. On three days, between April 16 and May 4, I observed only:

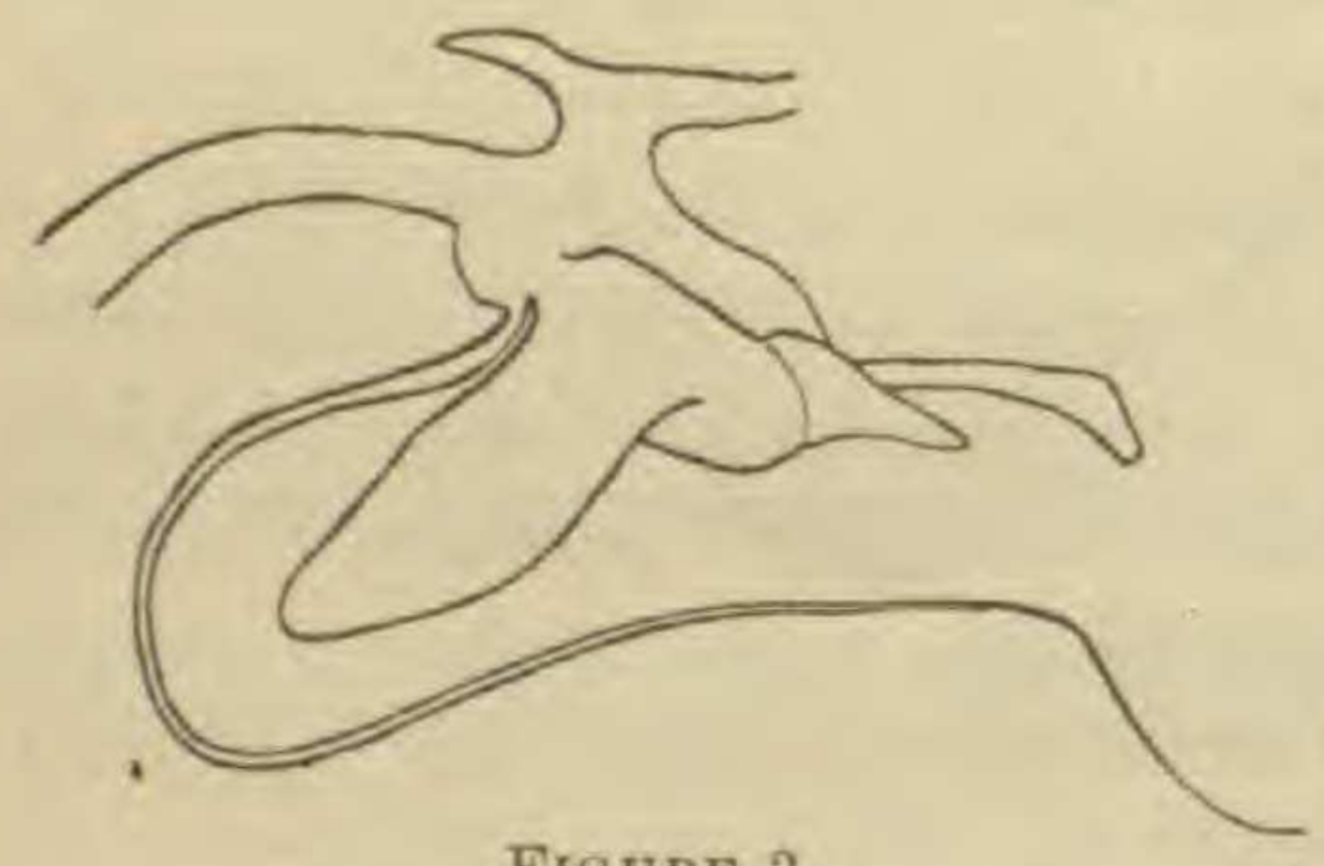

FIGURE 3.

Hymenoptera—*Apidæ:* (1) Synhalonia honesta Cress. ♂, s.; (2) Osmia albiventris Cress. ♀, s. and c. p., ab.; (3) O. atriventris Cress. ♀, s.; (4) O. montana Cress. ♀, s. and c. p. *Andrenidæ:* (5) Andrena sp. ♀, s.; (6) Halictus coriaceus Sm. ♀, s. and c. p.

Diptera—*Bombylidæ;* (7) Bombylius fratellus Wied. s.

Lepidoptera—*Rhopalocera:* (8) Colias philodice Godt.—all reversing except nos. 1, 7 and 8.

Viola pedata L. var. *bicolor* Gray (fig. 4).—The flowers are larger than in any of the preceding species. The two upper petals are of a deep purple, the others blue, the handsome flowers bearing a resemblance to the pansy. The lateral petals are not bearded. The lower petal is deeply grooved and is produced behind into a curved spur from 4 to 8 mm. long. The strong style and the anthers project considerably and oppose the way to the nectar, so that the extent of concealment of the nectar is determined by the distance from the tip of the style to the tip of the spur—a distance of from 12 to 16 mm. The staminal spurs are about 4 mm. long and are very slender. The spur of the lower petal is slender and strongly compressed so as to narrow its cavity. As might be expected, the visitors are the longest-tongued bees, though butterflies often occur. The pollen is shed on the base of the proboscis of the insect.

FIGURE 4.

Hymenoptera—*Apidæ:* (1) Bombus virginicus Oliv. ♀ (14)[2]; (2) B. separatus Cress. ♀ (11–13); (3) B. pennsyl-

[2]Numbers in parenthesis after the name of the bee indicate the length of the proboscis in mm.

vanicus DeG. ♀ (16–17), ab.; (4) Anthophora ursina Cress. ♀ (18), s. & c. p., ab.; (5) Synhalonia speciosa Cress ♂ ♀ (13–15), all sucking in an upright position.

Lepidoptera—*Rhopalocera:* (6) Pyrameis cardui L., once, reversing; (7) Colias philodice Godt., sometimes reversing; (8) Nisoniades icelus Lintn., ab.; (9) N. juvenalis F., both always reversing. *Noctuidæ:* (10) Plusia simplex Guen., once, not reversing. On four days, between April 28 and May 3.

Eristalis latifrons eats stray pollen which falls upon lower petal.

Viola lanceolata L.—At Orlando, Fla., Feb. 17, I found it visited by Hymenoptera—*Andrenidæ:* (1) Halictus capitosus Sm. ♀, s. Lepidoptera—*Rhopalocera:* (2) Phyciodes tharos Dru.; (3) Pamphila sp.

General notes on the foregoing violets.—In a paper on the cause of floral irregularity,[3] Viola was mentioned as an exception to the rule that irregular polypetalous flowers have the nectary on the upper side. I think the spur was developed in a way analogous to the galea of Aconitum, *i. e.* on the upper side of the flower, and that it has changed to the lower side as a result of inversion of the flower. The weight of the spur itself may have had something to do with turning the flower upside down. Not only would the flower be expected to have been originally sternotribe from my theory, but it is still properly so, for in most cases it is so formed that bees are required to turn upside down to reach the nectar. Fig. XI of the title page of Sprengel's "Entdeckte Geheimniss" shows a flower of V. odorata with a hive-bee sucking in a reversed position. The spur seems to have become so closely fitted to the bee that after inversion the bee was forced to turn head downwards in order to extract the sweets.

On the part of the flower, the resupinate position seems to be advantageous in enabling it to sift the pollen down upon the insect, instead of exposing it to pollen-eating intruders. Under V. tricolor, Müller says: "The anthers, which together form a cone, shed their pollen into this groove (*i. e.* of the lower petal), either of themselves or when the pistil is shaken by the insertion of the bee's proboscis." It seems to me that the action to which the mechanism is adapted to give

[3] Bot. Gaz., XIII., 207.

rise, and the only action which will insure that the pollen shall be applied to the same side of the proboscis which touches the stigma, is that the pollen discharge shall be effected by the bee itself.

On the part of the visitors, the inversion seems particularly favorable to bees of the genus Osmia, and I am inclined to consider the flowers of V. pubescens, palmata and striata as specially adapted to them, in spite of the presence of other visitors. Now, these bees have their pollen-collecting hairs situated on the ventral surface of the abdomen, so that the position which they must take to suck is the one which enables them to receive the pollen and apply it to their scopæ most conveniently. For this reason, species of Osmia are the most abundant and most useful visitors. Indeed, for the species referred to, I am convinced that Osmia albiventris and atriventris are of more importance than all of the other visitors put together. Müller mentions bees of this genus as visitors of V. odorata, canina and tricolor, var. arvensis.

Delpino (178)[4] has discovered that the beards on the lateral petals are intended for the bee to cling to when it turns head downwards. He rightly regards the bees which reverse as legitimate visitors, and considers the action of Anthophora pilipes on V. tricolor as illegitimate, since it inserts its proboscis without turning. Really, the proper visitors are bees which are small enough to use the beard as a support; so that the humble-bees and butterflies may properly be classed as intruders, even when they reverse. For the proper visitors of the bearded violets we must look to small bees, among which the Osmias are most important.

Remembering that the bearded violets are sternotribe, it is interesting to observe that they become nototribe with respect to all visitors, like Anthophora and Bombylius, which fail to reverse, and this enables us to understand how a properly nototribe violet might be produced. V. pedata is a violet of this sort, being visited mainly by long-tongued bees, which light upon the spurred petal and remain upright. The lateral petals have lost their beards, since they are no longer of use to the bees. The flower still retains the upward curvature of the spur as an ancestral characer. If the spur had been developed with reference to visitors acting like most of those now seeking it, I think it would curve down rather

[4] Numbers in parenthesis after an author's name are the numbers of titles in Thompson's Bibliography. See Müller: Fertilization of Flowers, pp. 599-634.

than up. The effect of the upward curvature of the spur is well illustrated in the behavior of Nisoniades, which invariably turn head downwards.

It has often occurred to me that Bombylius could suck the bearded violets more easily than the insects which reverse, and that under certain conditions it might take possession of them, as Anthophora and Bombus have done in the case of V. pedata. In this connection, it is interesting to refer to Müller's observations on V. calcarata. He saw Macroglossa stellatarum visit 194 flowers of this violet in 6¾ minutes. So rapid a visitor might easily take possession of any flower which suits its fancy. V. calcarata appears to have become completely adjusted to a new set of conditions, for its spur, as shown in Müller's figures, turns downward, and not upwards as in V. pedata.

Claytonia Virginica L.—The proterandry of this flower was first recorded by Bessey (87). He concludes that the adaptations are to favor cross-fertilization and to prevent self-fertilization, and my observations confirm his view. On the other hand, Meehan, in a paper on "The 'Sleep of Plants' as an Agent in Self-fertilization" (485), regards it as commonly self-fertilized by closing of the petals. This mode of self-fertilization was discussed by Ch. Fermond[5] in 1859, but C. Virginica is a very poor example of it. Indeed, it is most erroneous to suppose that it is commonly self-fertilized in this way, for it is one of the most marked cases of proterandry in native plants.

On the first day the stamens stand in the center of the flower and the anthers discharge their pollen, but the lobes of the stigma remain closed. The flower is visited very abundantly by insects which suck up the honey and which eat or collect the pollen, so that by the time the flower closes the pollen is commonly all removed. On the second day the stamens are bent over, holding the empty anther against the petals. The stigma lobes are now separated, and the flower is in the second or female stage. If self-fertilization by closing of the flower occurs, it is after the anthers have been exposed to insects for two days and the stigma for one, but many flowers which I marked exposed their stigmas again on the third day, showing that fertilization of any kind had failed on the day before. The flowers are therefore male on the first day and female on the second and sometimes on the third.

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[5] See Just's Bot. Jahresbericht, IV, 939.

Moreover, Meehan states that he did not see the flowers visited by insects—an observation easy to make on any flower. The plants grow in large patches and are very attractive to a great variety of insects. The nectar is not deep seated, so that rather short tongues can reach it. On 26 days, between April 8 and May 11, the following visitors were observed:

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s. and c. p.; (2) Bombus virginicus Oliv. ♀; (3) B. vagans Sm. ♀; (4) B. pennsylvanicus De G. ♀; (5) Synhalonia honesta Cress. ♂; (6) S. speciosa Cress. ♀; (7) Ceratina dupla Say ♂; (8) Osmia lignaria Say ♂ ♀; (9) O. albiventris Cress. ♂ ♀; (10) Nomada bisignata Say ♀; (11) N. luteola St. Farg. ♂ ♀, all only sucking, except no. 1. *Andrenidæ:* (12–20) Andrena spp., s. and c. p., ab.; (21) Agapostemon radiatus Say ♀, s and c. p.; (22) Augochlora pura Say ♀, s.; (23) A. lucidula Sm. ♀, s.; (24) Halictus sp. ♀, s. and c. p.; (25) H. coriaceus Sm. ♀, do.; (26) H. fasciatus Nyl? ♀, do.; (27) H. pilosus Sm. ♀, do,; (28) H. connexus Cress. ♀, do.; (29) Colletes inæqualis Say ♂ ♀, s.

Diptera—*Stratiomyidæ:* (30) Sargus viridis Say. *Bombylidæ:* (31) Bombylius fratellus Wied., s. *Conopidæ:* (32) Myopa vesiculosa Say, s. *Empidæ:* (33–35) Empis spp. s. *Syrphidæ:* (36) Melanostoma obscurum Say; (37) Syrphus arcuatus Fall.; (38) S. ribesii F.; (39) S. americanus Wied.; (40) Allograpta obliqua Say; (41) Mesograpta marginata Say; (42) M. geminata Say; (43) Sphærophoria cylindrica Say; (44) Eristalis dimidiatus Wied.; (45) E. latifrons Lu.; (46) Helophilus similis Macq.; (47) Syritta pipiens L.—all sucking and feeding on pollen. *Tachinidæ:* (48) Gonia frontosa Say, s. *Sarcophagidæ:* (49) sp., s.; (50, 51) Sarcophaga spp., s. *Muscidiæ:* (52) Lucilia cæsar L.; (53) L. cornicina Mgn.; (54) L. ruficeps Mgn., all s. *Anthomyidæ:* (55–57) spp., s. *Cordyluridæ:* (58) Scatophaga squalida Mgn., s. *Sepsidæ:* (59) Sepsis sp. *Drosophilidæ:* (60) Drosophila sp.

Lepidoptera—*Rhopalocera:* (61) Phyciodes tharos Dur.; (62) Pyrameis atalanta L.; (63) Lycæna comyntas Godt.; (64) Papilio ajax L.; (65) Pieris protodice Bd.-Lec.; (66) P. rapæ L.; (67) Colias philodice Godt.; (68) Nisoniades icelus Lintn.; (69) N. juvenalis F.—all s.

Coleoptera—*Chrysomelidæ:* (70) Megilla maculata De G. *Curculionidæ:* (71) Centrinus sp.

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